**Effect of Sodium Nitroprusside (SNP) Treatment on Shelf-Life Extension and Quality Preservation of Jamun (*Syzygium cumini* Skeels) Fruits During Cold Storage**

**Abstract**

*Syzygium cumini* Skeels, commonly referred to as Indian blackberry, Jamun, or Java Plum, is a medicinally significant fruit indigenous to India, characterized by its high content of hydrolysable tannins, flavonoids, anthocyanins, gallic acid, and quercetin. Despite its nutritional benefits, the fruit's perishable nature restricts its postharvest viability to 3–4 days under ambient conditions. To enhance shelf life and maintain quality during cold storage, a study was conducted wherein fully ripe jamun fruits were subjected to postharvest dipping in sodium nitroprusside (SNP) solutions at concentrations of 0.5 mM, 1.0 mM, and 1.5 mM for 5 minutes. Post-treatment, the fruits were air-dried and stored in low-density polyethylene (LDPE) film bags at 7 ± 1°C. Control fruits were either immersed in distilled water and stored in open LDPE bags or sealed bags at the same temperature. The results indicated that the 1.5 mM SNP treatment was most efficacious, sustaining physicochemical and functional quality parameters such as reducing physiological weight loss (4.66% after 15 days), preserving ascorbic acid content (31.06 mg/100g), retaining antioxidant capacity (6.65 mg TE/100g FW), and maintaining phenolic content (297.66 mg GAE/100g FW) for up to 30 days. Furthermore, the 1.5 mM SNP treatment effectively preserved total soluble solids (TSS%) at 14.43% and anthocyanin content at 27.52 mg/100g FW at 30 days after storage (DAS). These findings present substantial advantages for farmers and traders by mitigating postharvest losses and facilitating long-distance marketing, while also improving consumer access through an extended shelf life.

**Keywords:** Jamun, Phytochemical, Sodium nitroprusside, Low-density polyethylene, Shelf-life

**Introduction**

Indian blackberry (*Syzygiumcumini* Skeels), a significant evergreen tropical fruit crop of the Myrtaceae family with a chromosome number of 2n = 40, is indigenous to India and cultivated globally in tropical and subtropical regions such as West Africa, West Indies, South America, Eastern Africa, Florida, Israel, and California due to its high commercial value (de Carvalho Tavares *et al*., 2016). The oblong berries feature purplish-black skin, purplish-pink or white pulp, and a hard seed, and are rich in water-soluble vitamins (e.g., vitamins C, B1, B2), minerals (e.g., iron, calcium, phosphorus, potassium, sodium, zinc), sugars, fiber, amino acids, anthocyanins, and phenolic compounds (e.g., tannins, flavonoids, gallic acid). The pulp is used to produce jams, jellies, wines, squashes, ready-to-serve beverages, and sauces. Medicinally, jamun offers benefits including blood sugar regulation due to alkaloids like jambosin and glycoside in seeds (Koley *et al*., 2011), blood pressure management, and treatment of heart, liver, and lung diseases (Raza *et al*., 2015). Despite these advantages, approximately 0.5 million tons of jamun are lost postharvest due to its perishable nature, lasting only 2–3 days at room temperature (Patil *et al*., 2012). Harvesting occurs from June to August with the onset of rains (Koley *et al*., 2011), but the fruit’s rapid deterioration and perishability hinder transportation to distant markets, compelling orchard owners to sell at low prices (Rai *et al*., 2011). Recent postharvest strategies to extend shelf life and reduce losses include calcium chloride and gibberellic acid applications (Ayar *et al*., 2011), edible coatings with antioxidants (Baraiya *et al*., 2015), modified atmosphere packaging (Rai *et al*., 2011), and salicylic acid combined with chitosan coatings to delay senescence (Saurabh *et al*., 2019).

Nitric oxide (NO), a multifunctional plant signaling molecule synthesized via enzymatic and non-enzymatic pathways, regulates physiological processes and responses to biotic and abiotic stresses (Nabi *et al*., 2019). Exogenous NO donors, such as sodium nitroprusside (SNP), have been shown to delay ripening and senescence, preserving the physicochemical and functional quality of fruits and vegetables during storage (Palma *et al*., 2019). Consequently, this study investigates the efficacy of SNP in delaying senescence and maintaining the physicochemical and functional quality of jamun fruit under low-temperature storage.

**Materials and methods**

Jamun fruits were harvested at full ripening stage in July 2019 from ~20-year-old trees and immediately transported to the Postharvest Laboratory, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University. Uniform, healthy fruits free from blemishes, pests, diseases, and mechanical injury were selected. Fruits were surface disinfected with 2% sodium hypochlorite for 2 minutes, air-dried, and subsequently treated with aqueous sodium nitroprusside (0.5 mM, 1.0 mM, 1.5 mM), for 5 minutes. Control fruits were immersed in distilled water under the same conditions. After air-drying at room temperature, the fruits were packaged in low-density polyethylene (LDPE) and stored at low temperature (7±1⁰C). During storage under low temperature conditions, the observation results of different physical, chemical and functional quality attributes are recorded every 5 days.

**Weight loss (WL)**

Fruit weight loss (%) was determined by measuring the difference between the initial weight and the weight recorded on each sampling day (Ziaolhagh, 1999). It was calculated using the formula: Weight Loss (%) = [(IW − FW) / IW] × 100, where IW represents the initial weight of the fruit and FW is the fruit weight at the time of sampling. The result was expressed as a percentage to indicate the proportion of weight lost during storage.

**Decay loss**

Decay loss is assessed based on fungal growth or the appearance of symptoms of decay, regardless of its severity (Ziaolhagh, 2021). The result is expressed as a percentage (%) and calculated using the given formula. Decay loss (%) = (Number of fruit spoiled/Total number of fruits under observation) ×100.

**Malondialdehyde content**

Malondialdehyde (MDA) content, a marker of lipid peroxidation, was measured using the Zheng and Tian (2006). Approximately 0.5 g of jamun fruit tissue (peel and pulp) was homogenized in 5 mL of 5% (w/v) trichloroacetic acid (TCA), then centrifuged at 10,000 rpm for 15 minutes to obtain the supernatant. A 2 mL aliquot of the supernatant was mixed with 2 mL of a 5% TCA and 0.6% (w/v) thiobarbituric acid (TBA) solution, incubated at 90°C, and rapidly cooled. The volume was adjusted to 4 mL with TCA-TBA solution, and absorbance was read at 450 nm and 532 nm using a spectrophotometer. MDA concentration was calculated and expressed as nmol/g FW.

**Total soluble solids and titratable acidity**

The total soluble solids (TSS) of jamun fruits during storage were determined using a digital refractometer (Atago, Tokyo, Japan), with results expressed in degrees Brix (°Brix), reflecting the sugar concentration in the juice.

**Total anthocyanins content**

To estimate the total anthocyanin content, 0.05 g of peel and 0.5 g of pulp were taken separately and mixed with 10 ml of ethanolic HCl (Lees and Francis, 1972). Then store the solution at low temperature overnight. Subsequently, the sample was centrifuged at 10,000rpm for 10 minutes, and the absorbance was recorded at 535 nm. The total anthocyanins content was expressed as mg/100 g FW.

**Ascorbic acid content**

Jones and Hughes (1983) designed a procedure for the determination of ascorbic acid in fruits. For this, 0.2 g of fruit samples were mixed with 3% w/v metaphosphoric acid solution and make the volume up to 20 ml. From this, 10 ml aliquot was taken and titrated with 2,6-dichlorophenol indophenol dye to the pink end point. The ascorbic acid content of the fruit, expressed in mg/100 g FW.

**Total phenolics content**

Total phenolic content was determined following Singleton *et al*. (1999). A 0.5 g fruit sample was extracted with 10 mL of 80% ethanol. An aliquot (100 µL) was mixed with 2.9 mL distilled water and 0.5 mL 1 N Folin–Ciocalteu reagent. After 3 minutes, 2 mL of 20% Na₂CO₃ was added, and the mixture was incubated for 90 minutes. Absorbance was measured at 760 nm, and results were expressed as mg gallic acid equivalents (GAE) per 100 g fresh weight.

**Total flavonoids content**

Total flavonoid content was estimated following Zhishen *et al*. (1999). A 0.5 g fruit sample was extracted with 10 mL methanol and centrifuged at 10,000 rpm for 10 minutes. To 1 mL supernatant, 4 mL distilled water and 0.3 mL of 5% NaNO₂ were added. After 5 minutes, 0.3 mL of 10% AlCl₃·6H₂O was added, followed by 1 mL of 1 N NaOH after 6 minutes. The volume was adjusted to 10 mL, and absorbance was read at 510 nm. Results were expressed as mg rutin equivalents (RE) per 100 g fresh weight.

**Total antioxidant capacity**

Total antioxidant capacity was determined using the copper reducing antioxidant capacity (CUPRAC) method, as described by Apak *et al*. (2008). In a test tube, 100 µL of 80% ethanolic extract of jamun, 1 mL each of copper (II) chloride solution, neocuproine solution, ammonium acetate buffer, and distilled water were mixed. The mixture was incubated for 30 minutes, after which absorbance was measured at 450 nm. The results were expressed as micromoles of Trolox equivalents (µmol TE) per gram of fresh weight (FW).

**Analysis of data**

The experiment was organized using a completely randomized design, consisting of 5 treatments with 3 replicates per treatment. Data for different parameters are presented as mean ± standard error. To compare the treatment means, the Tukey's Honest Significant Difference (HSD) test was applied. A p-value of ≤ 0.05 was considered indicative of a statistically significant difference. All statistical analyses were performed using the SAS 9.2 software (SAS Institute, Cary, NC, USA).

**Results and discussion**

**Weight loss**

Postharvest weight loss significantly impacts the qualitative and quantitative quality of jamun fruit, primarily due to rapid water loss, thin skin, and shrinkage after harvest. Jamun pulp contains 80.14–81.32% moisture (Shahnawaz and Sheikh, 2011), and weight loss is driven by respiration, transpiration, and cellular decomposition, which degrade storage quality and accelerate senescence (Tareen *et al*., 2012; Baraiya *et al*., 2015; Gol *et al*., 2015).The investigation assessed the effect of postharvest treatments on physiological weight loss in jamun fruit under low-temperature storage. Table 1 illustrates that the physiological loss in weight (PLW%) increased over a 30-day period, with the most substantial losses observed in the Control Open group, reaching up to 23.3% at 25 days after storage (DAS). The sealing of control samples effectively reduced weight loss by limiting moisture evaporation. All sodium nitroprusside (SNP) treatments (0.5, 1.0, and 1.5 mM) further mitigated PLW, with the 1.5 mM SNP treatment proving to be the most efficacious, resulting in only 3.47% loss at 25 DAS and 0.07% at 30 DAS. These findings suggest that SNP, particularly at a concentration of 1.5 mM, significantly reduces postharvest weight loss by delaying senescence and decelerating metabolic activity. Additionally, Leshem *et al*. (1998) reported that low nitric oxide (NO) levels enhance plant growth, improve stress tolerance, and postpone senescence, while high levels suppress growth and hasten deterioration. NO also reduces postharvest water loss, preserves nutrient content, and delays aging in fruits and vegetables. This result is consistent with findings in persimmon, peach, and mango (Berman *et al*., 2014; Shahkoomahally *et al*., 2015; Ren *et al*., 2017; Saba *et al*., 2017).

**Decay loss**

The delicate skin of the jamun fruit renders it highly susceptible to mechanical damage and microbial infection following harvest. Both treated and control fruits exhibited no signs of decay for up to 15 days when stored at low temperatures. Table 1 illustrates that decay loss commenced after 15 days of storage and exhibited a significant increase by 30 days, particularly in untreated samples. The Control Open group experienced the highest decay at 34.30%, whereas sealing the control reduced decay to 20.30%. SNP treatments substantially mitigated decay, with the 1.5 mM SNP treatment demonstrating the most favorable outcome, resulting in only 5.73% decay at 30 DAS. This finding suggests that SNP, especially at a concentration of 1.5 mM, is highly effective in reducing postharvest decay and extending shelf life.SNP demonstrated superior efficacy over controls in curbing decomposition, likely attributable to the induction of reactive oxygen species (ROS) by exogenous nitric oxide (NO), which inhibits the growth of *P. expansum* (Lai *et al*., 2011). Furthermore, the low oxygen levels, augmented by SNP, contribute to the suppression of fungal growth (Wells and Uota, 1970; Barkai-Golan, 1990). The effectiveness of SNP in reducing decay is corroborated by studies on mango (Ren *et al*., 2017) and kiwi (Zheng *et al*., 2017).

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| Parameters | Treatments | Days after storage (DAS) |
| **5 DAS** | **10 DAS** | **15 DAS** | **20 DAS** | **25 DAS** | **30 DAS** |
| Physiological loss in weight (%) | **Control Open** | 2.53 ± 0.12 a | 5.07 ± 0.25 a | 11.4 ± 0.4 a | 17.2 ± 0.52 a | 23.3 ± 0.41 a | 1.39 ± 0.80 a |
| **Control Sealed** | 0.59 ± 0.08 b | 1.35 ± 0.18 b | 2.6 ± 0.10 b | 5.4 ± 0.33 b | 6.64 ± 0.18 b | 0.46 ± 0.26 b |
| **SNP (0.5 mM)** | 0.66 ± 0.02 b | 0.81 ± 0.03 b | 1.42 ± 0.23 c | 3.19 ± 0.21 c | 3.93 ± 0.19 c | 0.38 ± 0.22 c |
| **SNP (1.0 mM)** | 0.65 ± 0.09 b | 0.68 ± 0.13 b | 1.35 ± 0.10 c | 2.80 ± 0.42 c | 3.39 ± 0.02 c | 0.40 ± 0.23 c |
| **SNP (1.5 mM)** | 0.30 ± 0.05 b | 0.78 ± 0.07 b | 1.19 ± 0.05 c | 2.81 ± 0.02 c | 3.47 ± 0.11 c | 0.07 ± 0.04 c |
| Decay loss (%) | **Control Open** | 0 | 0 | 0 | 11.18 ± 0.68 a | 17.29 ± 0.44 a | 34.30 ± 2.12 a |
| **Control Sealed** | 0 | 0 | 0 | 7.76 ± 0.20 b | 9.9 ± 0.37 b | 20.30 ± 1.12 b |
| **SNP (0.5 mM)** | 0 | 0 | 0 | 4.43 ± 0.74 c | 8.80 ± 0.23 b | 15.91 ± 0.24 c |
| **SNP (1.0 mM)** | 0 | 0 | 0 | 3.98 ± 0.30 c | 8.78 ± 0.91 b | 13.89 ± 0.51 c |
| **SNP (1.5 mM)** | 0 | 0 | 0 | 1.84 ± 0.17 d | 3.6 ± 0.35 c | 5.73 ± 0.15 d |
| Malondialdehyde content (nmol/ g) | **Control Open** | 2.82 ± 0.14 a | 3.93 ± 0.20 a | 5.00 ± 0.09 a | 6.21 ± 0.20 a | 7.44 ± 0.23 a | 9.73 ± 0.08 a |
| **Control Sealed** | 2.53 ± 0.07a | 3.61 ± 0.18ab | 3.95 ± 0.14 b | 5.29 ± 0.15 b | 6.69 ± 0.14 a | 9.20 ± 0.28 ab |
| **SNP (0.5 mM)** | 2.38 ± 0.27 a | 3.33 ± 0.12ab | 3.95 ± 0.18 b | 4.87 ± 0.17 b | 6.57 ± 0.20 a | 8.59 ± 0.17 b |
| **SNP (1.0 mM)** | 2.40 ± 0.12 a | 3.09 ± 0.29 ab | 3.66 ± 0.23 b | 4.62 ± 0.09 b | 5.28 ± 0.21 b | 7.64 ± 0.09 c |
| **SNP (1.5 mM)** | 2.42 ± 0.18 a | 2.99 ± 0.09 b | 3.39 ± 0.05 b | 4.59 ± 0.18 b | 5.09 ± 0.15 b | 6.51 ± 0.13 d |

**Table 1. Effect of sodium nitroprusside (SNP) treatments on physiological loss in weight (%), decay loss (%) and malondialdehyde content (nmol/ g) of jamun fruit during low-temperature storage.**

**Malondialdehyde content**

Malondialdehyde (MDA), a stable product of lipid peroxidation, serves as a key biomarker for oxidative stress in biological samples (Ahmadi-Motamayel *et al*., 2020; Tsikas *et al*., 2023). This study observed a progressive rise in MDA content during jamun fruit storage (Table 1), with significant increases across all treated and control fruits. The data concerning malondialdehyde (MDA) content, a marker of lipid peroxidation and oxidative stress, indicates a consistent increase over the 30-day storage period across all treatments. The Control Open group persistently exhibited the highest MDA levels, reaching 9.73 nmol/g at 30 DAS, signifying the most pronounced membrane damage. The Control Sealed and SNP (0.5 mM) treatments demonstrated slightly lower MDA accumulation, whereas SNP at 1.0 mM and particularly at 1.5 mM significantly reduced MDA levels. The 1.5 mM SNP treatment consistently maintained the lowest MDA content (6.51 nmol/g) throughout 30 days after storage. This finding suggests that higher concentrations of SNP effectively mitigate oxidative damage and preserve cellular integrity during storage. Exogenous nitric oxide (NO) application protected lipoproteins and membranes from oxidation, reducing MDA in SNP-coated fruits (Mansouri, 2012).

**Total anthocyanins content in fruit peel and pulp**

The anthocyanins content in fruit peel is responsible for the red, purple, or blue colors of many fruits, and it has been reported to have various health benefits due to its antioxidant and anti-inflammatory properties. The total peel anthocyanin content decreased in all treatments during the storage period, with the control fruit peel showing a more rapid degradation of anthocyanins compared to SNP-treated fruit. A comparison of the treatments revealed that the higher concentration (1.5 mM) of SNP resulted in a slower decline in peel anthocyanins (Fig. 1). The maximum retention of peel anthocyanins (368.26 mg/100 g FW) was observed in fruit treated with 1.5 mM SNP, whereas the minimum retention (273.13 mg/100 g FW) was found in fruit stored without treatment and packaging.

The results of this study indicate that the total anthocyanin content in the pulp of all treated and untreated jamun fruit declined rapidly during storage, with the fruit control showing the fastest decline regardless of storage conditions. In contrast, fruit treated with 1.5 mM SNP had significantly higher anthocyanin retention compared to those treated with lower concentrations (Fig. 2). No significant difference in anthocyanin content was found in the fruit pulp during the first 25 days of storage. On the 30th day of storage, fruit treated with 1.5mM SNP had significantly higher anthocyanin retention (6.41 mg/100 g FW)compared to the control (open packet) jamun fruit, which had the lowest level of anthocyanins (4.87 mg/100 g FW).Enhanced anthocyanin retention in SNP-treated jamun fruit may result from reduced moisture loss, which prevents membrane breakdown and plasmolysis (Sun *et al*., 2010). Excessive moisture loss leads to anthocyanin leakage from vacuoles, degrading into melanin via PPO, POD, and anthocyanase. Phenylalanine ammonia lyase (PAL), crucial for anthocyanin biosynthesis (Dixon and Paiva, 1995), is linked to increased anthocyanin accumulation through elevated PAL activity.

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**Fig. 1. Effect of sodium nitroprusside (SNP) on total peel anthocyanin content (mg/100gFW) of jamun fruit during storage at low temperature.**

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**Fig. 2. Effect of sodium nitroprusside (SNP) on total pulp anthocyanin content (mg/100gFW) of jamun fruit during storage at low temperature.**

**Total soluble solids**

Total soluble solids (TSS) in fruit comprise a range of organic compounds, including organic acids, sugars, pigments, and other salts, that are soluble in water. According to Noomrio and Dahot (1996), the primary sugars present in jamun are maltose, fructose, sucrose, galactose, glucose, and mannose. The study revealed that sodium nitroprusside (SNP) treatments influenced the retention of total soluble solids (TSS) in jamun fruit during cold storage. The data from Table 2 concerning total soluble solids (TSS%) over a 30-day period reveals distinct trends across different treatments. In the Control Open group, TSS initially increased to 17.63% at 15 days after storage (DAS) before declining to 12.86% by 30 DAS, which may indicate potential over-ripening followed by degradation. The Control Sealed samples exhibited slightly more stable TSS levels, although a decline was still observed over time. Treatments with SNP were more effective in maintaining TSS, with the 1.5 mM SNP treatment demonstrating the most consistent values throughout the storage period. By 30 DAS, the 1.5 mM SNP treatment retained the highest TSS at 14.43%, suggesting a delayed ripening effect. Overall, SNP treatments, particularly at 1.5 mM, proved effective in preserving TSS content and, consequently, fruit quality during storage. This treatment might have slowed down the respiration rate and other metabolic changes that occurred in the fruit during postharvest storage, thus maintaining higher TSS content over others. The loss of total soluble solids in response to postharvest SNP treatment was also found in mango (Zaharah and Singh, 2011; Ren *et al.*, 2017)

**Ascorbic acid content**

Ascorbic acid levels in jamun fruit declined progressively throughout the storage period, with untreated (control) samples exhibiting a more rapid loss compared to those treated with SNP. The data from Table 2 regarding ascorbic acid content indicates a gradual decline across all treatments over the 30-day storage period. The Control Open group exhibited the most rapid decrease, with levels dropping from 58.80 mg/100g at 5 DAS to 21.99 mg/100g at 30 DAS. Sealing the control samples slightly mitigated this decline. SNP treatments proved more effective in preserving ascorbic acid, with higher concentrations providing enhanced protection. The SNP 1.5 mM treatment maintained the highest levels throughout storage, retaining 31.06 mg/100g at 30 DAS. These findings suggest that SNP, particularly at 1.5 mM, significantly delays the degradation of ascorbic acid, thereby preserving nutritional quality during storage. The antisenescence effect of NO released from SNP may have also contributed to the greater preservation of ascorbic acid. The ability of SNP to slow down the depletion of ascorbic acid has been observed in other fruits like mango (Zaharah and Singh, 2011; Ren *et al*., 2017).

**Total phenolics content**

Jamun fruit is rich in phenolic compounds, including flavonoids, anthocyanins, and tannins, which enhance its antioxidant activity and nutraceutical value (Baraiya *et al*., 2015). As shown in Table 2, The data on phenolic content (mg GAE/100g FW) indicates a steady decline across all treatments during the 30-day storage period, with notable differences in the rate of loss. The Control Open group experienced the most rapid degradation, decreasing from 440.66 mg at 5 DAS to 225.33 mg at 30 DAS. The Control sealed group performed slightly better, ending with 229.66 mg. In contrast, SNP treatments significantly slowed the decline in phenolics. SNP at 0.5 mM and 1.0 mM retained higher levels than controls, with final values of 261.33 mg and 276.33 mg, respectively. The best results were seen with SNP at 1.5 mM, which maintained the highest phenolic content throughout storage—from 471 mg at 5 DAS to 297.66 mg at 30 DAS. These findings highlight those higher concentrations of SNP, especially 1.5 mM, are effective in preserving phenolic compounds, likely due to their role in minimizing oxidative stress and delaying degradation processes during postharvest storage.SNP treatment postponed the breakdown of phenolic compounds by lowering the activities of polyphenol oxidase (PPO), peroxidase (POD), and phenylalanine ammonia lyase (PAL), thus preserving elevated phenol levels in fruit during storage (Duan *et al*., 2007). The protective role of SNP against phenolic compound loss has also been documented in fruits like persimmon (Shahkoomahally *et al*., 2015) and mango (Hu *et al*., 2014).

**Total flavonoids content**

Flavonoids, potent secondary metabolites with strong antioxidant properties, are abundant in jamun fruit, including flavanols like dihydromyricetin diglucoside, dihydroquercetindiglucoside, and dimethyl dihydromyricetin diglucoside, supporting its widespread use in the medicinal industry (Jagetia, 2017). This study observed a continuous decline in total flavonoid content during storage in both treated and control jamun fruit, with a notable drop in open-packet controls (Fig. 3). SNP treatment delayed this loss, maintaining higher flavonoid levels than controls over the first 20 days, though differences among SNP concentrations were not significant. By the storage end, 1.5 mM SNP-treated fruits showed the highest retention (35.13 mg RE/100 g FW), significantly surpassing 0.5 mM, but not differing significantly from 1.0 mM. Enhanced flavonoid retention in SNP-treated fruit may be linked to elevated peroxidase, phenylalanine ammonia lyase, and chitinase activities (Hu *et al*., 2014).

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**Fig..3 Effect of sodium nitroprusside (SNP) on total flavonoids content (mg CE/100gFW) of jamun fruit during storage at low temperature.**

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| Parameters | Treatments | Days after storage (DAS) |
| **5 DAS** | **10 DAS** | **15 DAS** | **20 DAS** | **25 DAS** | **30 DAS** |
| Total soluble solids (%) | **Control Open** | 14.5 ± 0.11 ab | 16.26 ± 0.17 a | 17.63 ± 0.17 a | 16.93 ± 0.18 a | 13.93 ± 0.52 a | 12.86 ± 0.18 b |
| **Control Sealed** | 14.36 ± 0.08 ab | 15.6 ± 0.41ab | 16.03 ± 0.23 b | 15.7 ± 0.32 b | 14.2 ± 0.20 a | 13.33 ± 0.24 ab |
| **SNP (0.5 mM)** | 15 ± 0.20 a | 14.96 ± 0.26 ab | 15.23 ± 0.27 bc | 15.73 ± 0.12 b | 14.56 ± 0.37 a | 13.5 ± 0.40 ab |
| **SNP (1.0 mM)** | 13.8 ± 0.37 b | 14.63 ± 0.55 b | 15.2 ± 0.25 bc | 15.16 ± 0.26 b | 14.86 ± 0.41 a | 13.9 ± 0.28 ab |
| **SNP (1.5 mM)** | 14.8 ± 0.20 ab | 14.9 ± 0.15 ab | 14.66 ± 0.14 c | 15.33 ± 0.31 b | 14.93 ± 0.34 a | 14.43 ± 0.27 a |
| Ascorbic acid content (mg/ 100 g) | **Control Open** | 58.80 ± 2.15 a | 48.10 ± 1.00 b | 41.50 ± 1.12 a | 34.63 ± 1.21 a | 27.08 ± 1.12 a | 21.99 ± 1.19 b |
| **Control Sealed** | 60.62 ± 0.83 a | 54.63 ± 0.88 ab | 44.44 ± 1.05 a | 35.42 ± 2.54 a | 31.20 ± 2.22 bc | 22.42 ± 1.50 b |
| **SNP (0.5 mM)** | 58.74 ± 2.43 a | 51.47 ± 1.40 ab | 44.64 ± 1.05 a | 37.36 ± 1.51 a | 35.35 ± 1.77 ab | 26.26 ± 2.01 ab |
| **SNP (1.0 mM)** | 62.07 ± 0.64 a | 55.06 ± 2.22 ab | 48.51 ± 1.69 a | 39.07 ± 1.13 a | 34.91 ± 2.55 ab | 27.05 ± 1.23 ab |
| **SNP (1.5 mM)** | 63.10 ± 1.40 a | 56.22 ± 1.75 a | 47.54 ± 1.48 a | 41.44 ± 1.35 a | 38.64 ± 1.37 a | 31.06 ± 1.26 a |
| Phenolics content (mg GAE/100g FW) | **Control Open** | 440.66 ± 7.21 a | 370.66 ± 11.05 b | 351.66 ± 6.71 b | 319.66 ± 11.46 a | 278.66 ± 5.48 b | 225.33 ± 4.09 d |
| **Control Sealed** | 460.33 ± 12.91 a | 404.66 ± 22.39 ab | 357.66 ± 14.11 ab | 326 ± 5.19 a | 270.66 ± 11.21b | 229.66 ± 11.97cd |
| **SNP (0.5 mM)** | 462.33 ± 3.52 a | 404.33 ± 5.23 ab | 363.33 ± 6.17 ab | 332.66 ± 11.60 a | 294 ± 9.29 ab | 261.33 ± 7.31 bc |
| **SNP (1.0 mM)** | 466.66 ± 8.25 a | 427 ± 5.19 ab | 391 ± 5.50 ab | 345 ± 17.09 a | 325.33 ± 7.88 a | 276.33 ± 6.64 ab |
| **SNP (1.5 mM)** | 471 ± 7.02 a | 439.66 ± 8.95 a | 392 ± 7.81 a | 352 ± 11.01 a | 323.66 ± 5.23 a | 297.66 ± 6.35 a |

**Table 2. Effect of sodium nitroprusside (SNP) on to**tal **soluble solids (%), ascorbic acid content (mg/ 100 g) and total flavonoid content (mg CE/100g FW) of jamun fruit during storage at low temperature.**

**Total antioxidant capacity and Radical scavenging activity (DPPH)**

Assessing the antioxidant capacity of jamun fruit provides critical insights into its nutritional and health benefits, driven by anthocyanins, phenolics, flavonoids, and ascorbic acid. As depicted in Fig. 4, total antioxidant capacity declined progressively during storage across all treatments. Up to 10 days, antioxidant levels in treated and control fruits were similar. By day 15, fruits treated with 1.0 mM and 1.5 mM SNP showed significantly higher antioxidant capacity than those with 0.5 mM SNP or untreated, with 1.5 mM SNP maintaining the highest levels thereafter. At the storage end, 1.5 mM SNP-treated fruits achieved the highest antioxidant capacity (6.65 mg TE/100 g FW), not significantly different from 1.0 mM SNP (6.39 mg TE/100 g FW).

Jamun fruit treated with 1.5 mM SNP exhibited significantly higher antioxidant capacity throughout storage compared to controls, likely due to delayed senescence, which preserved phenolic compounds, flavonoids, and ascorbic acid. Similar findings in persimmon (Shahkoomahally *et al*., 2015) and mango (Zaharah and Singh, 2011; Barman *et al*., 2014) link high antioxidant capacity to better retention of these compounds. The progressive decline in antioxidant capacity during storage correlates with reduced levels of phenolics, flavonoids, anthocyanins, and ascorbic acid (Barman *et al*., 2014).

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**Fig. 4. Effect of sodium nitroprusside (SNP) on total antioxidant capacity (mg TE/100gFW) of jamun fruit during storage at low temperature.**

**Conclusion**

This study, titled “Effect of Sodium Nitroprusside Treatments on Postharvest Quality and Storage Life of Jamun,” was conducted under low-temperature storage conditions. The findings demonstrate that postharvest application of sodium nitroprusside (SNP) effectively preserved jamun fruit quality and extended shelf life. Among the concentrations tested (0.5, 1.0, and 1.5 mM), 1.5 mM SNP proved most effective, significantly reducing weight loss and decomposition while enhancing total soluble solids, ascorbic acid, titratable acidity, and bioactive compounds such as anthocyanins, phenols, flavonoids, and antioxidant capacity. Overall, 1.5 mM SNP emerged as the optimal concentration for maintaining postharvest quality and extending the storage duration of jamun fruit.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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